authorization is hereby given to charge any such deficiency or additional fee to our Deposit Account No. 01-0268.

REMARKS

In the last Office Action, dated February 20, 2001, claims 1, 3, 8 and 9 were rejected under 35 U.S.C. §102(a) as being clearly anticipated by Takagi ('360). Claim 2 was rejected under 35 U.S.C. §102(a) as being anticipated by each of Katsuma, Hirano and Mukohjima. Claims 4-6 were rejected under 35 U.S.C. §103(a) as being unpatentable over Takagi ('360). The Examiner stated that Takagi teaches the claimed ultrasonic motor structure except that the support 30 is not disclosed as being an integral part of the substrate 50. The Examiner took the position that it is within the skill expected of the routineer to make parts integral or separable.

Claim 7 was rejected under 35 U.S.C. §103(a) as being unpatentable over Miyazawa, Katsuma or Hirano in view of Wada, Kumasaka ('179) or Kumasaka ('909). The Examiner stated that each of the references to Miyazawa, Katsuma and Hirano discloses an ultrasonic motor mounted on a printed circuit board but does not explicitly teach that drive circuit elements are also provided on the board. The Examiner pointed out, however, that Wada and Kumasaka teach that it is well known to place the drive circuit for a piezoelectric device on

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the same circuit board that supports the device to save space and make solid state manufacturing and connections more easy. In view of this disclosure, the Examiner has taken the position that it would have been obvious to one of ordinary skill in the art that the printed circuit boards of Miyazawa, Katsuma or Hirano could be expanded to include drive circuit elements.

In addition to the foregoing rejections, claims 10-13 and 17-21 were rejected under 35 U.S.C. §102 as being unpatentable over Toda, Vishnevsky ('580), Kumada or Vishnevsky ('073); claims 14 and 15 were rejected under 35 U.S.C. §103 as being unpatentable over Vishnevsky ('073) or Toda; and claim 16 was rejected under 35 U.S.C. §103 as being unpatentable over Vishnevsky ('073) or Toda in view of Wada, Kumasaka ('179) or Kumasaka ('909). The Examiner stated that Vishnersky ('073) and Toda teach the vibration motor but not mounted on a PCB which, for the same reasons given in regard to claim 7, would have been obvious to provide in Vishnersky or Toda with a PCB substrate.

By the present response, independent claims 1, 10 and 20 have been amended to more particularly point out and distinctly claim the novel subject matter of the present invention. Amended claims 1 and 20 further recite that the substrate has a conductor pattern for conveying a drive signal from a drive circuit, and that the support member mechanically

supports the piezoelectric element on the substrate and transmits the drive signal from the conductor pattern formed on the substrate to the piezoelectric element. Amended independent claim 10 now recites that the structure of the piezoelectric vibrator, i.e., that the vibrator is a laminated structure formed of one or more piezoelectric elements polarized to undergo expansion-and-contraction vibration in response to the drive signal and one or more piezoelectric elements polarized to undergo flexural vibration in response to the drive signal, and further recites that the piezoelectric vibrator is disposed so that a side face thereof is in contact with the movable member and undergoes elliptical movement in response to the drive signal to drive the movable member.

Submitted herewith is an attachment captioned **"Version With Markings to Show Changes Made"** including marked-up versions of claims 1, 10 and 20 showing the changes made thereto by the present response. In response to the Examiner's request for a substitute specification, applicants have also submitted herewith a substitute specification consisting of the original specification re-typed in smooth form to incorporate revisions made thereto during prosecution. Also enclosed is a marked-up scanned version of the original specification showing the changes made thereto. Applicants'

undersigned attorney hereby states that the substitute specification does not contain impermissible new matter.

To obtain a fuller scope of coverage, new claims 22-32 have been added. Adequate support for the subject matter recited in these claims may be found in the specification as originally filed.

Applicants respectfully submit that claims 1-21 and newly added claims 22-32 patentably distinguish over the prior art of record.

As described by applicants at pages 1-2 of the specification, the conventional piezoelectric ultrasonic motor utilizes conductive wires as signal transmitting means for conveying a drive signal produced by a drive circuit to the piezoelectric element. Typically, an elastic member such as a spring is used to bias the piezoelectric element against a movable member to efficiently transmit drive power produced by vibration of the piezoelectric element to the movable member so as to drive the moving member. When such an ultrasonic motor is mounted on a circuit board, it is held to the board by a support member that holds the piezoelectric element in place.

In the conventional ultrasonic motor it is necessary to include conductive wires as signal transmission means, support means for holding the piezoelectric element in place with respect to the movable member, and an elastic member for

maintaining a biasing force between the piezoelectric element and the movable member. This structure is needed to support and hold the piezoelectric element in a given position with respect to the movable member and to transfer a drive signal to the piezoelectric element. The use of separate components to accomplish these tasks leads to an increase in the size of the ultrasonic motor. In addition, since loss in the expansion-and-contraction movement of the piezoelectric element occurs through both the support member and the conductive wires, the use of separate components results in an increased loss.

The present invention overcomes the foregoing problems by providing an ultrasonic motor with a support member capable of serving two or more of the aforementioned functions. According to the present invention, the support member not only supports the piezoelectric element on a substrate, but also has the ability to transmit a drive signal to the piezoelectric element so that no conductor wires are needed. The support member thus transmits the drive signal to the piezoelectric element. In addition, the support member can be formed of a resilient material or a flexible portion so that it resiliently urges the piezoelectric element against the movable member, thereby eliminating the need for a separate elastic member for biasing the piezoelectric element and movable member. Accordingly, the present invention makes

it possible to substantially reduce the size of the ultrasonic motor and reduces the loss associated with the use of multiple components as described above.

An embodiment of the inventive ultrasonic motor is shown in Fig. 1 of the application drawings. The motor includes a rectangular piezoelectric element 10 that receives a drive signal X to undergo elliptical vibration. Support members 11, 11 hold the piezoelectric element 10 on a substrate 7 and deliver signals through signal lines 7a, 7b printed on the substrate 7. A symmetry member 12 has a movable member 12a in contact with an end of the piezoelectric element 10. A drive circuit IC 6 is provided on the substrate 7 to supply the drive signal X to the piezoelectric element 10 through the signal lines 7a, 7b and conductors formed on the support members 11, 11.

In operation, the ultrasonic motor 1 operates by elliptic vibration of the end face of the piezoelectric element 10 produced in response to the drive signal X to move the movable member 12a in a direction parallel to the end face.

The support members 11, 11 may be formed of a resin material in an L-shaped form and each may be provided with three signal lines formed on a surface thereof. The support members 11, 11 have six signal lines and six corresponding

electrodes are formed on side faces of the piezoelectric element 10.

The support members 11, 11 have one side 11a fixed to the signal line 7a of the substrate 7, such as by solder, and the other side 11b fixed to a side of the piezoelectric element 10 by means of a conductive adhesive or the like. The support members 11, 11 thus hold the piezoelectric element 10 to the substrate 7 and connect between electrodes of the piezoelectric element 7 and the signal lines 7a or 7b. The support members 11, 11 thus serve to support the piezoelectric element and further serve as signal transmission means for transmitting the drive signal X to the piezoelectric element 10. As a result, the number of components of the ultrasonic motor is reduced, and the size and loss factor of the motor are also reduced.

The piezoelectric element 10 has a first piezoelectric vibrator 14 serving as a flex vibration source and a second piezoelectric vibrator 15 laminated thereon and serving as an expansion-and-contraction vibration source. The piezoelectric element 10 has electrodes 13a-13f respectively connected to the six electrodes on the substrate 7 and the support members 11, 11 to cause the respective vibrators 14, 15 to undergo vibration. This combination of vibration sources produces the elliptical motion of the piezoelectric element 10.

The cited references fail to disclose the subject matter recited by amended independent claims 1, 10 and 20, or much of the subject matter recited in various ones of the dependent claims.

Amened claims 1, 10 and 20 each recite subject matter that is not disclosed in the cited references. As pointed out above, amended claims 1 and 20 recite that the substrate has a conductor pattern for conveying a drive signal from a drive circuit, and that the support member mechanically supports the piezoelectric element on the substrate and transmits the drive signal from the conductor pattern formed on the substrate to the piezoelectric element.

Amended independent claim 10 recites that the piezoelectric vibrator is a laminated structure formed of one or more piezoelectric elements polarized to undergo expansion-and-contraction vibration in response to the drive signal and one or more piezoelectric elements polarized to undergo flexural vibration in response to the drive signal, and further recites that the piezoelectric vibrator is disposed so that a side face thereof is in contact with the movable member and undergoes elliptical movement in response to the drive signal to drive the movable member.

Claims 1, 3, 8 and 9 are not anticipated by Takagi '360 since the cited reference to Takagi '360 requires the use of conductive wires in addition to a support member extending

from a substrate to support a piezoelectric element and transmit a drive signal to the piezoelectric element. Amended independent claim 1 explicitly recites that conductive wires are not used for this purpose and that the support member transmits the drive signal.

Similarly, none of the cited references to Kutsuma, Hirano, Mukohjima, Miyazawa, Katsuma, Hirano, Wada, Kumasaka ('179), Kumasaka ('909), Toda, Vishnevsky ('580), Kumada, or Vishnevsky ('073) discloses or suggests an ultrasonic motor which eliminates the need for the use of conductive wires extending from a drive circuit to a piezoelectric element. Nor do these references, alone or in combination, disclose or suggest the structure of the piezoelectric element recited in amended independent claim 10.

With respect to the Examiner's conclusion that it is within the level of routine skill to make parts integral or separable, applicants respectfully point out that the claims do not recite structure that is the mere integration of separate parts. Amended claims 1 and 20 require a substrate having a conductor pattern for conveying a drive signal from a drive circuit, a piezoelectric vibrator provided on the substrate, and a support member for supporting the piezoelectric vibrator and transmitting the drive signal to the piezoelectric vibrator. Nothing in the cited references would have suggested this combination of elements.

Anticipation under 35 U.S.C. §102 requires the identical disclosure by a single prior art reference of all elements of a rejected claim arranged exactly as recited in the claim. W.L. Gore & Associates v. Garlock, Inc., 220 USPQ 303, 313 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) ("Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration"); Lindemann Maschinenfabrik GmbH v. American Hoist & Derrick Co., 221 USPQ 481, 485 (Fed. Cir. 1984) ("Anticipation requires the presence in a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim") (emphasis added).

Since Takagi (360), Kutsuma, Hirano and Mukohhima fail to identically disclose the subject matter recited in amended independent claim 1, the anticipatory rejection of claims 1, 3-6, 8 and 9 should not be maintained.

An obviousness rejection requires a showing that each and every limitation in a rejected claim would have been obvious, and must be based on a showing in the prior art of some teaching, reason, suggestion, or motivation to make a modification which renders an invention obvious within the meaning of 35 U.S.C §103. See, e.g., Symbol Technologies, Inc. v. Opticon, Inc., 935 F.2d 982, 989, 18 USPQ2d 1885 (Fed. Cir. 1991). The cited references fail to identically disclose the subject matter of claims 1, 10 and 20, and fail to support

the conclusion that the modifications needed to replicate the combinations recited in claims 1, 10 and 20 would have been obvious. As described above, the ultrasonic motor of claims 1 and 20 is provided with a support member that transmits a drive signal to the piezoelectric element and <u>no conductive wires are used</u>. The inventive ultrasonic motor of these claims has an improved driving force, a reduced vibrational loss and smaller dimensions as compared with conventional ultrasonic motors. In the Fig. 1 embodiment, the piezoelectric vibrator 10 generates a rotational driving force in response to a received drive signal. A drive signal for driving the piezoelectric element 10 is transmitted along leads 7 to a support member 11. The support member 11 supports, and is in electrical connection with, the piezoelectric vibrator 10 on the substrate 8. Thus, the support member is effective for both supporting the piezoelectric member 10 and for transmitting the drive signal from a conductor pattern formed on the substrate to the piezoelectric vibrator 10. The movable member 12 contacts the piezoelectric vibrator 10 and moves in response to the vibrational driving force. There is simply no teaching or motivation in the references for making any of the modifications necessary to achieve the claimed combinations. Thus, there is no support for a continued obviousness rejection of the claims.

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Moreover, various dependent claims define separately patentable subject matter. In one embodiment of the inventive ultrasonic motor, the support member is comprised of an elastic material effective to elastically urge the piezoelectric vibrator against the movable member. Nothing similar is found in the cited references. The support member may include a relatively thinner constriction portion and a relatively thicker connection portion, the constriction portion being effective for decreasing vibration losses. This is effective to provide the resilient biasing force.

The support member may also be incorporated as part of the substrate, wherein the substrate has a recess portion in which the piezoelectric vibrator is disposed to reduce the overall thickness of the motor. No corresponding structure is found in the cited references. Also, the support member may be configured for supporting the piezoelectric vibrator at a flex vibration node of the piezoelectric vibrator to reduce vibrational loss.

Thus, in accordance with the present invention an improved ultrasonic motor is provided having reduced vibrational loss, smaller dimensions and improved driving force as compared with the conventional art. The inventive ultrasonic motor may be incorporated in an electronic appliance, such as (but not limited to) an electronic

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timepiece, a measuring instrument, a camera, a printer, a printing machine, a machine tool, a robot, a moving apparatus and a memory device.

In view of the foregoing amendments and discussion, the application is now believed to be in condition for allowance. Accordingly, favorable reconsideration and allowance of the claims are most respectfully requested.

Respectfully submitted,

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MAILING CERTIFICATE

I hereby certify that this correspondence is being deposited with the United States Postal Service as first-class mail in an envelope addressed to: Commissioner of Patents & Trademarks, Washington, D.C. 20231, on the date indicated below.

Bruce L. Adams
Attorney Name

Signature

MAY 21, 2001
Date

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS:

Claims 1, 10 and 20 have been amended as follows:

1. (Twice Amended) An ultrasonic motor, comprising: a movable member disposed to undergo movement in response to a drive force; a substrate having a conductor pattern for conveying a drive signal from a drive circuit; a piezoelectric vibrator provided on the substrate for undergoing oscillating movement in response to the [an input] drive signal so as to contact the movable member and generate the [for generating a] drive force to drive the movable member; and a support member provided on the substrate for mechanically supporting the piezoelectric vibrator on the [a] substrate and transmitting the drive signal from the conductor pattern [, the support member having a signal transmission function to transmit the drive signal] to electrodes of the piezoelectric vibrator so that no conductor wires extend from the substrate to connect the drive circuit and the piezoelectric vibrator.

10. (Amended) An ultrasonic motor, comprising: a substrate; a piezoelectric vibrator disposed on the substrate to undergo vibration in response to a drive signal; a support member for supporting the piezoelectric vibrator on the

substrate, the support member being effective to transmit the drive signal to the piezoelectric vibrator; and a movable member disposed on the substrate <u>adjacent</u> [in contact with] the piezoelectric vibrator and driven in response to vibration of the piezoelectric vibrator<u>; wherein the piezoelectric vibrator comprises one or more piezoelectric elements polarized to undergo expansion-and-contraction vibration in response to the drive signal laminated to one or more piezoelectric elements polarized to undergo flexural vibration in response to the drive signal, and the piezoelectric vibrator is disposed so that a side face thereof is in contact with the movable member and undergoes elliptical movement in response to the drive signal to drive the movable member</u>.

20. (Amended) An electronic appliance incorporating an ultrasonic motor, comprising: an ultrasonic motor comprising <u>a movable member disposed tor undergo movement in response to a drive force,</u> a substrate <u>having a conductor pattern for conveying a drive signal from a drive circuit</u>, a piezoelectric vibrator disposed on the substrate to undergo vibration in response to <u>the</u> [a] drive signal <u>so as to contact the movable memver and generate the drive force to drive the movable member</u>, a support member <u>provided on the substrate</u> for <u>mechanically</u> supporting the piezoelectric vibrator on the substrate <u>and transmitting the drive signal from the conductor</u>

pattern [, the support member being effective to transmit the drive signal] to electrodes of the piezoelectric vibrator so that no conductor wires extend from the substrate to connect the drive circuit and the piezoelectric vibrator; [, and a movable member disposed on the substrate in contact with the piezoelectric vibrator and driven to undergo movement in response to vibration of the piezoelectric vibrator;] an output mechanism for outputting a motion; and a transmission mechanism for transmitting movement of the movable member to the output mechanism.

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1 **ULTRASONIC MOTOR AND ELECTRONIC APPLIANCE**

2 **WITH ULTRASONIC MOTOR**

3 BACKGROUND OF THE INVENTION

4 1. Field of the Invention

5 [This] The present invention [relates] pertains to ultrasonic motors used for
6 timepieces, cameras, printers, memory devices and so on [and
7 more] More particularly, the present invention pertains to [an] ultrasonic motor [which is] with reduced [in
8 vibration [leak] inefficiency to more efficiently transmit a drive force to a moving
9 member, [but made in small in size with improved reliability.]

10 2. Description of the Related Art

11 [The] A conventional ultrasonic motor utilizes, as power to move a moving
12 member, elliptic vibration that is a resultant vibration of
13 expansion-and-contraction vibration and flex vibration caused
14 on a piezoelectric element applied by a drive signal such as
15 an alternating current voltage. Recently, [attentions have] attention has
16 [being] been drawn to [the] ultrasonic motors particularly in the field
of micro-mechanics, because of their high electric-to-mechanical energy conversion efficiency.

17 [The] A conventional ultrasonic motor generally has a piezoelectric element as a drive power source, a signal transmission means for transmitting drive signals to the piezoelectric element, and an elastic member for pressure-contacting the piezoelectric element with the moving member to efficiently transmit drive power to the moving member.

Where such a ultrasonic motor is installed on a circuit board, such as a printed circuit board, it is held on the circuit board by using a support member to hold one part of a vibrator having a piezoelectric element for of the ultrasonic motor. that holds the

However, there has been a necessity for it is necessary the conventional ultrasonic motor to provide the piezoelectric element with a signal transmission part, such as conductor wires, to apply a drive signal to the piezoelectric element. That is there As a result encountered leakage loss of occurs the expansion-and-contraction vibration and flex vibration caused on the piezoelectric element to an outside through both the support member and the signal transmission part. The In addition leakage of loss the expansion-and-contraction vibration and flex vibration was also occurs through the elastic member to the outside.

As a result, the a conventional ultrasonic motor could does not efficiently transmit drive force to the moving member, and thus impaired in ultrasonic motor characteristic of high impairing the electric-to-mechanical energy conversion efficacy.

Meanwhile Further, mounting a plurality of elements on the piezoelectric element prevented against prevents size reduction for the ultrasonic motor and hence increased factors to lower its decreases the reliability of the motor.

Accordingly, it is an object of the present invention to provide a an ultrasonic motor which is decreased in factors to leak with reduced loss of the drive force produced on a piezoelectric element and so as to efficiently

transmit the drive force to a moving member, and wherein size reduction and improvement in reliability are achieved.

SUMMARY OF THE INVENTION

[That is, the means to solve the problem is characterized by a] In accordance with the present invention, an ultrasonic motor is provided that includes [, as claimed, comprises:] a piezoelectric vibrator for oscillating [due to] in response to an input drive signal. [and generating] The oscillating piezoelectric vibrator generates a drive force. [; and a] A support member [for supporting] supports the piezoelectric vibrator on a substrate. [; wherein the] The support member also [has a signal transmission function to transmit] transmits the drive signal to the piezoelectric vibrator.

[Here, the] The support member is formed, for example, of a resin having on [a] its surface a signal line or it is formed of a metal so as to have a signal transmission function.

[Meanwhile, the] The piezoelectric vibrator is formed, for example, only by a piezoelectric element. Alternatively, the piezoelectric vibrator may be formed as a metal vibrator bonded to a piezoelectric element [may be applied thereto]. The drive control may be either of a self-oscillation type or a separately-oscillation type.

According to this invention, because the drive signal is transmitted through the support member to the piezoelectric vibrator, there is no need to separately providing a signal transmission part.

Accordingly, loss of the expansion-and-contraction vibration and flex vibration caused on the piezoelectric vibrator is reduced [in leak amount to an outside] as compared to the conventional ultrasonic motor.

Therefore, the ultrasonic motor according to the invention efficiently transmits a drive force caused on the piezoelectric vibrator to the moving member.

in accordance with the present invention, there is no need for

Also, ~~the unnecessity of~~ separately providing a signal transmission part ~~offers~~ size ~~reduction for~~ of the ultrasonic motor and ~~hence~~ further ~~decrease in~~ the number of manufacture processes resulting in reduction in manufacture ~~cost~~. — the inventive ultrasonic motor

thus decreasing the

decreasing the cost to

~~Next, the present invention is characterized in that, in the aforesaid~~ Also, in accordance with the present inventive ultrasonic motor, the support member ~~has elasticity,~~ is elastic and the piezoelectric vibrator ~~being~~ is press-contacted with ~~a~~ the moving member by ~~an~~ the elastic force of the support member.

The ~~method to provide the~~ elastic support member ~~with elasticity includes using as a~~ is comprised of an elastic material, for example, a conductive rubber or the like.

~~According to this invention, a function is available equivalent to that of the above invention.~~ In addition, the piezoelectric vibrator is urged ~~on~~ toward the moving member by the elasticity of the support member. Accordingly, the drive force caused on the piezoelectric vibrator is transmitted to the moving member with higher efficiency.

~~Next, the present invention is characterized in that,~~ Also, in accordance with the ~~aforesaid~~ inventive ultrasonic motor, the support member has a constriction portion that is ~~made thin~~ thinner than a connection portion connected to the piezoelectric vibrator.

Accordingly,

[According to this invention, the provision of] (the constriction portion of [in] the support member reduces the vibration transmission area [in] of (the support member so [that the constriction reduces the leak] as to reduce the loss of vibration [furthermore]. Consequently, the ultrasonic motor transmits a drive force to the moving member with higher efficiency. Furthermore, the support member deforms due to the constriction portion [, and has an operation equivalent to that of the above invention].

Furthermore, the present invention [is characterized in that,] in accordance with in the aforesaid ultrasonic motor, [the support member is a part of the substrate.

[Acceding to this invention] thus, because the support member is a [one] part of the substrate, the ultrasonic motor is easy to mount on the substrate.

Furthermore, in accordance with the present invention, [is characterized in that, in the aforesaid ultrasonic motor,] the piezoelectric vibrator is provided in a recess formed in the substrate.

In accordance with this aspect of the invention [Here], the piezoelectric vibrator is mounted such that the surface of the substrate and the surface of the piezoelectric vibrator are positioned in a same plane, through the support member formed as [one] a part of the substrate [which has been left without made in recess when forming a recess in the substrate].

[According to this invention, a similar operation is available to that of the above invention.] In addition, [there is decrease in] the thickness of the inventive ultrasonic motor [plus the] is decreased

substrate. Accordingly the application of the ultrasonic motor is broadened as compared to the conventional ultrasonic motor.

Furthermore, the present invention is characterized in that, in the aforesaid ultrasonic motor, the piezoelectric vibrator is mounted on the support member.

According to this aspect of the invention, a similar operation is available to that of the above invention. In addition, because the piezoelectric vibrator is mounted on the support member, the piezoelectric vibrator can be mounted on a substrate in a similar procedure to Manner as the conventional mounting of transistors or capacitors on a substrate. That is, in accordance with the ultrasonic motor of the present invention, it is possible to simultaneously mount a motor and circuits on a substrate by using an existing electric circuit production line. Accordingly, the ultrasonic motor is reduced in less expensive and more stable mounting cost and stabilized in mounting process. Consequenty, the inventive ultrasonic motor is reduced in variation of has better performance characteristics with improved reliability.

Further, the present invention is characterized in that, in the aforesaid ultrasonic motor, In accordance with the present invention the support member is provided with at least one part of a drive circuit.

According to this aspect of the invention, because the support member is provided with at least part of a drive circuit, the number of drive circuit elements required to be mounted on a substrate are decreased, thereby reducing the size of the ultrasonic motor. Also, there is reduction of variation in ultrasonic motor

performance resulting from a connection between the piezoelectric vibrator and the drive circuit. Further, circuit parts can be mounted and adjusted so as to adjust the variation in the motor and circuits, thus improving the reliability.

Further, [the preset invention is characterized in that, in the aforesaid ultrasonic motor,] in accordance with the present invention, the support member supports the piezoelectric vibrator at a point corresponding to a node of vibration caused thereon.

Here, the vibration includes, for example, flex vibration and expansion-and-contraction vibration.

According to this aspect of the invention, the support member holds the piezoelectric vibrator at a point corresponding to a node of flex vibration. Because there is no displacement in the node of vibration, there is further a decrease [in externally leaking] in the amount of vibration loss caused on the piezoelectric vibrator. Consequently, the ultrasonic motor can transmit a drive force caused on the piezoelectric vibrator to the moving member with higher efficiency.

Furthermore, [the present invention is characterized in that, in the aforesaid ultrasonic motor,] in accordance with the present invention, the ultrasonic motor is an electronic appliance having the aforesaid ultrasonic motor.

According to this aspect of the invention, because the aforesaid ultrasonic motor is used in which less vibration [leaks to an] is lost to the outside as compared to the conventional ultrasonic motor, the

has increased , efficiency

ultrasonic motor is increased in output. That is, because the ultrasonic motor and its drive circuit are reduced in size, the electronic appliance with ultrasonic motor is decreased in size.

BRIEF DESCRIPTION OF THE DRAWINGS

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Fig. 1 is a view showing a structure of a ultrasonic motor 1 according to a first embodiment of the present invention;

Fig. 2 is a view showing a structure of a piezoelectric vibrator 14 and piezoelectric vibrator 15 with electrodes 13a to 13f used in a piezoelectric element 10 for the ultrasonic
inventive
motor 1;

Fig. 3 is a schematic view showing operation of the
the
ultrasonic motor 1;

Fig. 4 is a view showing structural essential elements of a ultrasonic motor 2 as a modification to the ultrasonic motor
inventive
1;

an

Fig. 5 is a view showing a structure of a ultrasonic motor 3 according to a second embodiment of the present invention;

Fig. 6 is a view showing structural essential elements of a ultrasonic motor 4 as a modification to the ultrasonic motor
shown in Fig. 5;
3; and

Fig. 7 is a view showing a structure of an electronic
constructed an
appliance with ultrasonic motor 5 according to a third embodiment of the present invention;

DETAILED DESCRIPTION OF THE INVENTION

of the present invention

Embodiments will be explained in detail to which the invention is applied, with reference to Fig. 1 to Fig. 7.

Fig. 1 to Fig. 3 are figures for explaining a ultrasonic motor 1 as a first embodiment of the invention, while Fig. 4 is a figure showing a structure of a ultrasonic motor 2 as a modification of the ultrasonic motor 1.

an / configured

Meanwhile, Fig. 5 is a figure for explaining a ultrasonic motor 3 as a second embodiment of the invention, while Fig. 6 is a figure for explaining a ultrasonic motor 4 as a modification of the ultrasonic motor 3.

second embodiment of the invention / an / configured

Meanwhile, Fig. 7 is a figure for explaining an electronic appliance 5 with a ultrasonic motor as a third embodiment of the invention.

[EMBODIMENTS]

[First Embodiment]

Fig. 1 is a view showing an overall structure of a the ultrasonic motor 1.

the

As shown in Fig. 1 the ultrasonic motor 1 is structured by a piezoelectric element 10 (piezoelectric vibrator) that is inputted by drive signal X, such as a sine wave, to elliptically vibrate, support members 11, 11 that hold the piezoelectric elements 10 on a substrate 7 and deliver signals through signal lines 7a, 7b on the substrate 7, a symmetry member 12 having a moving member 12a contacted with an end face of the piezoelectric element 10 and a drive IC 6 provided on the

includes / receives a / support members 11 / A / has / A / is

substrate 7 to input drive signal X to the piezoelectric element 10 through the signal lines 7a, 7b and the support members 11, 11. Incidentally, the drive IC 6 outputs drive signal X to a predetermined portion of an electrode of the piezoelectric element 10, hereinafter referred to, according to a forward drive command, backward drive command and stop command to be externally inputted through signal lines 7c, 7d and 7e.

That is, the ultrasonic motor 1 is a ultrasonic motor which
In accordance with the present invention
causes elliptic vibration at the piezoelectric member 10 end face according to drive signal X given from the drive IC 6 thereby moving the moving member 12a in directions parallel to the end face.

First, the support members 11 are explained in detail.

The support members 11 are formed of a resin, for example, generally in a L-form and each having, for example, three signal lines on a surface. That is, the support members 11, 11 have, for example, totally 6 signal lines which number is same as the
the
number of electrodes provided on the side faces of the piezoelectric element 10.

to
The support member 11 has one side 11a fixed on the signal line 7a of the substrate 7, for example, through solder. Also, the support member 11 has the other side 11b fixed on a side face of the piezoelectric element 10, for example, through conductive adhesive in a manner holding a node of flexional vibration.

Meanwhile, the signal lines 7a, 7b are a bundle of three signal lines. This number of signal lines is the same as the number of electrodes provided on the piezoelectric element 10 one side face, hereinafter referred to, which signal lines are separately connected respectively to signal lines of the support member 11.

Due to this, the The support member 11 supports the piezoelectric element 10 on the substrate 7 and connects between the electrodes of the piezoelectric element 10 and the signal line 7a or signal line 7b.

In this manner, the support member 11 formed with the signal line also serves as a signal transmission means to transmit a signal to the piezoelectric element 10. Thus That is, the number of parts connected to the piezoelectric member 10 is reduced and hence the ultrasonic motor 1 is made smaller in size.

Next, the piezoelectric element 10 will be explained in detail.

The piezoelectric element 10 has a piezoelectric vibrator 14 provided as a flex vibration source laminated thereon with a piezoelectric vibrator 15 as an expansion-and-contraction vibration source in one body, and is structured having an electrode 13a, electrode 13b, electrode 13c, electrode 13d, electrode 13e and electrode 13f.

These electrodes 13a to 13f are respectively connected to the 6 signal lines provided on the support members 11, 11,' and voltages are to be individually applied thereto.

Incidentally, a projection may be formed [in] approximately in the center of the piezoelectric element 10 [at generally center] to contact with and drive the moving member 12a.

[Here, the] The piezoelectric vibrator 14, 15 and the electrodes 13a to 13f will be explained in detail, with reference to Fig. 2.

Fig. 2(a) is a view showing an arrangement of electrodes [in] on one face of the piezoelectric element 10. [Meanwhile,] Fig 2(e) is a view showing an [arranging position] arrangement of electrodes in the side face 10a (see (a) of the figure), while (f) of the figure is a view showing an [arranging position] arrangement of electrodes in the side face 10b (see (a) of the figure).

[Meanwhile,] Fig. 2(b) is a view showing one surface of the piezoelectric vibrator 14, while (d) of the figure shows the other surface of the piezoelectric vibrator 15. [Meanwhile,] Fig. 2(c) is a top view of the piezoelectric vibrator 15.

[First explained is a] A polarization structure [in] of each piezoelectric vibrator will next be explained.

The piezoelectric vibrator 14 is structured, as shown in Fig. 2(b), [of] divided into two in a vertical direction and also divided into two in a horizontal direction [into four], i.e. a polarization region 14a, a polarization region 14b, a polarization region

14c and a polarization region 14d that are to be polarized + at their top surfaces in a laminated direction.

Meanwhile, the piezoelectric vibrator 15 is structured, as shown in Fig. 2(d), having one polarization region almost ~~in~~ on an entire surface so that it can be polarized +, for example, ~~in~~ on an underside surface in the lamination direction.

Next ~~explained are~~ the structure~~s~~ of the electrodes 13a to 13f will be explained.

The electrode 13a ~~almost~~ substantially covers ~~over~~ a top surface of the polarization region 14a of the piezoelectric vibrator 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14a, 14a ... of a plurality of piezoelectric vibrators 14, 14 ..., at the top surfaces, are ~~to become~~ brought to a same potential by the electrode 13a continuing through extended portions to the side face 10b.

Similarly, the electrode 13b ~~almost~~ substantially covers over one surface of the polarization region 14b of the piezoelectric vibrator 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14b, 14b ... of the plurality of piezoelectric vibrators 14, 14 ..., at the one surfaces, ~~are to become~~ are brought to a same potential by the electrode 13b continuing through extended portions to the side face 10b.

Meanwhile, the electrode 13c ~~almost~~ substantially covers over ~~one~~ a surface of the polarization region 14c of the piezoelectric vibrator 14, one part of which is extended to a side face 10b.

That is, all the polarization regions 14c, 14c ... of the plurality of piezoelectric vibrators 14, 14 ..., at the one surfaces, ~~are to become~~ are brought to a same potential by the electrode 13c continuing through extended portions to the side face 10a.

Similarly, the electrode 13d ~~almost~~ substantially covers over one surface of the polarization region 14d of the piezoelectric element 14, one part of which is extended to a side face 10b. That is, all the polarization regions 14d, 14d ... of the plurality of piezoelectric vibrators 14, 14 ..., at the one surfaces, ~~are to become~~ are brought to a same potential by the electrode 13d continuing through extended portions to the side face 10a.

Also, the electrode 13e ~~almost~~ substantially covers over the other surface of the polarization region 15a of the piezoelectric vibrator 15, one part of which is extended to a side face 10a. That is, all the polarization regions 15a, 15a ... of a plurality of piezoelectric vibrators 15, 15 ..., at the other surfaces, ~~are to become~~ are brought to a same potential by the electrode 13e continuing through extended portions to the side face 10a.

Further, the electrode 13f is sandwiched between the other surface of the piezoelectric vibrator 14 and the one surface of the piezoelectric vibrator 15. Consequently, the electrode 13f covers over all the undersides of the four polarization regions 14a, 14b, 14c and 14d of the piezoelectric vibrator 14, and at the same time over the entire top surface of the polarization region 15a of the piezoelectric vibrator 15, ~~and~~

part of which is extended to the side face 10b. That is, all 2 the polarization regions 14d, 14d ... of the plurality of 8 piezoelectric vibrators 14, 14, at the top surfaces, are brought to 4 [become] a same potential by the electrode 13f continuing through the extended portions to the side face 10b.

Incidentally, the number of the piezoelectric vibrators 14, 15 may be increased appropriately. In this case, the electrode structure is changed depending on a lamination method.

Now, the operation of the ultrasonic motor 1 is explained using Fig. 3.

If the drive IC 6 is externally inputted by a drive command signal in a positive direction through the signal line 7c shown in Fig. 1, it outputs a drive signal X to the electrodes 13a, 13d, 13e and 13f of the piezoelectric element 10 through the signal lines 7a, 7b and the aforesaid signal lines on the support member 11.

Thereupon, in the piezoelectric vibrator 15 the drive signal X is inputted to the electrode 13e with respect to the electrode 13f as a reference electrode. Accordingly, the polarization region 15a expands or contracts. Consequenty, the piezoelectric vibrator 15 expands or contracts in a lengthwise direction as shown by [a rectangular] rectangle 15' in Fig. 3. 23

Simultaneously, in the piezoelectric vibrator 14 the drive signal X is inputted to the electrodes 13a, 13d with

respect to the electrode 13f as a reference electrode. Accordingly, the polarization regions 14a, 14d expands. Consequenty, the piezoelectric vibrator 14 effects flexional

4 vibration as shown by a rectangular rectangle 14' in Fig. 3.

5 At this time, the members only connected to the piezoelectric

6 element 10 is only the support members are 11, 11. Because no signal

7 transmission means is separately provided, vibration leak loss is reduced from the piezoelectric element 10.

As a result, the expanding-and-contracting vibration on the piezoelectric vibrator 15 and the flectional vibration on the piezoelectric vibrator 14 are combined so that the the piezoelectric element 10 at the end face effects elliptic vibration in a Z direction in Fig. 3, thereby moving the moving member 12a shown in Fig. 1 in the Z direction as a positive direction.

Also, if the drive IC 6 is externally inputted by a drive command in a reverse direction through the signal line 7d, it outputs a drive signal X to the electrodes 13b, 13c, 13e and 13f of the piezoelectric element 10 through the signal lines 7a, 7b and the aforesaid signal lines on the support member 11.

Thereupon, because the electrodes 13b, 13c are inputted by the drive signal X, the flex vibration of the piezoelectric vibrator 14 with respect to the expanding-and-contracting vibration as a reference of the piezoelectric vibrator 15 is reversed in direction from the positive direction case as

stated above. Accordingly, the piezoelectric element 10 at the end face effects elliptic vibration in a direction reverse to Z in Fig. 3, thereby moving the moving member 12a shown in Fig. 1 in a reverse direction.

As described above, according to a first embodiment of ~~the~~ inventive ultrasonic motor 1 ~~as a first embodiment of the present invention~~, because the drive signal X is delivered to the piezoelectric element 10 through the signal line 7a by the support member 11, there is no necessity of separately providing a signal transmission part. Accordingly, the loss of the expanding-and-contracting vibration and flex vibration ~~cased~~ caused on the piezoelectric element 10 ~~are reduced in amount of leak to an outside~~ is reduced, as compared to the conventional ultrasonic motor. Also, because the support members 11 are fixed in a manner holding a flex vibration node, the loss of the flex vibration caused on the piezoelectric element 10 is further reduced~~, in amount of leak to an outside.~~

Further, because there is no necessity of separately providing a signal transmission part, the ultrasonic motor 1 is reduced in size ~~, and also~~ along with the number of manufacture processes, thereby reducing manufacturing costs.

Accordingly, the ultrasonic motor 1 effectively transmits a drive force generated on the piezoelectric element 10 to the moving member 12a.

Incidentally, in ~~the~~ this embodiment of the present invention, although the support member 11 was made of a resin, the present

invention is not limited to this and may be of a metal, for example. In this case, the number of support members 11 has to be provided corresponding to the number of electrodes.

Further, the support member 11 may be provided with an entire or one part of an electric circuit, e.g. self-oscillation transmitting circuit. In this case, the number of elements to be provided on the substrate decreases, and the required substrate area ~~required~~ decreases. Accordingly, the ultrasonic motor 1 is further reduced in size.

~~Incidentally, the~~ The present embodiment may be modified as below.

Fig. 4 is a view showing a structure of elements of a ultrasonic motor 2 of a first modification to the present embodiment.

The ultrasonic motor 2 is made by a structure, in the ultrasonic motor 1, using support members 21 in place of the support members 11.

The support members 21 ~~is~~ are formed with a constriction in a generally I-form in the support member 11 with other parts structured similar to those of the support member 11. ~~That is,~~ Thus the support members 21 possess elasticity. Also, the support members 21 are fixed at side faces of the piezoelectric element 10 so that they can deflect in a direction parallel to the side face of the piezoelectric element 10.

Accordingly, the support members 21 press~~es~~ the piezoelectric element 10 against the moving member 12a (~~omittedly~~ not shown in Fig. 4).

That is, the ultrasonic motor 2 ~~as~~ has an equivalent function ~~to~~ as the ultrasonic motor 1. Further, because the piezoelectric element 10 is put in pressure contact with the moving member 12a by the support members 21, there is an increase of frictional force acted on between the piezoelectric element 10 and the moving member 12a. Accordingly, the drive force caused on the piezoelectric element 20 is conveyed to the moving member 12a with higher efficiency.

Also, the provision of the constriction decreases a vibration transmission area, further decreasing the loss ~~leak~~ of vibration through the support member 21. Accordingly, the ultrasonic motor 2 transmits a drive force to the moving member 12a with higher efficiency.

Incidentally, the method of providing elasticity to the support member 21 includes a method of forming a support member 21 of a conductive rubber with the shape of the support member 11 used as it is.

Also, the support member 21 may be provided with an entire or part of an electric circuit such as a self-oscillation transmitting circuit.

[Second Embodiment]

Fig. 5 is a view showing a schematic structure of elements of a second embodiment of the inventive ultrasonic motor 3.

The ultrasonic motor 3 is made [in] having a structure [that] with the piezoelectric element 30 is mounted on a substrate 8 having a recess by [using] support members 8b, 8b that are provided as [one] portions of the substrate 8 in the recess. Also, as shown in Fig 5(b), the piezoelectric member 30 has a top surface [almost] substantially in a same plane as that of a top surface of the substrate 8. Incidentally, other [not-shown] structural constituents [are] that are not shown [almost] substantially the same as those of the ultrasonic motor 1.

The support member 8b is structured, as shown in Fig 5(a), to have a support portion for holding the piezoelectric element 30 at a tip end of a terminal extended from the substrate 8. Due to this, the support member 8b is generally in a T-form in section in a parallel direction with the substrate 8. This substrate 8 is formed [in] having a predetermined form, for example, by [previously] preparing a forming mold for [a] the substrate 8 in a corresponding shape to [this]. Also, as shown in (b) [of the figure] the Fig 5, the support portion with T-Form shape described above is formed as a convex portion to support an underside of the piezoelectric element 30. [Meanwhile, one] One support member 8b has at a top face a signal line 8a to be connected to a part of the electrodes of the piezoelectric element 30, while the other support member 8b has at a top face [a] signal line[s] 8a, 8a to be connected to the remainder of the electrodes of the piezoelectric element 30. Incidentally, the

number of the signal lines 8a or support members 8b or their forming positions may be appropriately changed in accordance with the number of electrodes on the piezoelectric element 30 or a vibrational node position.

Here, the support member 8b is provided so ~~tat~~ that it holds a flex vibration node on the piezoelectric element 30, similarly to the support member 11.

The piezoelectric element 30 has almost the same structure as that of the piezoelectric element 10 except for a structure of extending electrodes to end faces 30a, 30b.

Here, when required, a signal line is passed through a hole 8d opened in the substrate 82 so that the signal line is connected to an electrode provided on a backside of the piezoelectric element 30.

That is, if a drive signal X is inputted through signal lines 8a, 8a, 8a to the electrodes of the piezoelectric element 30, the piezoelectric element 30 at the end face effects elliptic vibration to thereby move the moving member (not shown) that is in contact with the end face.

As described above, because in the ultrasonic motor 3 the support members 8b, 8b serves also as a signal transmitting means alike in the ultrasonic motor 1, the loss of the expanding-and-contracting vibration and flex vibration ~~occurred~~ occurring on the piezoelectric element 30 is reduced [in leak amount to an outside] as compare to the conventional ultrasonic motor. Further, because the support

members 8b are provided in a manner holding a flex vibration node, the flex vibration caused on the piezoelectric element is further loss of the reduced in leak amount to the outside.

Accordingly, the ultrasonic motor 3 can efficiently transmit the drive force caused in the piezoelectric element 30 to the moving member.

Also, because the piezoelectric element 30 is provided in the recess of the substrate 8 such that the piezoelectric element 30 and the substrate 8 at their top surfaces are in a same plane, the total thickness of the ultrasonic motor 3 and the substrate 8 are decreased, making the size small. Consequently, the application range of the ultrasonic motor 3 broadens as compared to that of the conventional ultrasonic motor.

Incidentally, the support member 8b may be formed with a constriction in a manner similarly to the support member 21, or the support member 8b only may be formed of conductive rubber. In this case, because the piezoelectric element 30 is pressed against the moving member by the support member 8b, there obtains a further increase in the transmission efficiency of drive force to the moving member is obtained.

Furthermore, the support member 8b may be provided with an entire or one part of an electric circuit such as a self-oscillation generating circuit. In this case, the number of elements on the substrate decreases is decreased to decrease a reducing the required substrate

area [required]. Accordingly, the ultrasonic motor 3 is made further smaller in size.

[Incidentally, the] The present embodiment may be further modified as follows.

Fig. 6 is a view showing a schematic structure of essential elements of a ultrasonic motor 4 of a first modification according to the present embodiment. Incidentally, the structural constituents not shown are [in almost] substantially the same structure as those of the ultrasonic motor 1.

In Fig. 6, the ultrasonic motor 4 is structured such that the piezoelectric element 40 is fixed, corresponding to nodes of flex vibration of the piezoelectric element 40, on surfaces of the support members 8c, 8c ... provided in a recess of a substrate 8 using, for example, solder, as shown in Fig. 6(b).

The support member 8c is structured having a [support] piezoelectric element 40 support portion provided at a tip of an extension terminal extended from the substrate 8, as shown in Fig. 6(a). The support portion has a top face that is [Flash] flush with the top face of the substrate 8. Due to this, the sectional [form] shape in a parallel direction to the substrate 8 is generally a T form.

Also, a predetermined signal line 8a is provided on a surface of the support member 8c corresponding to an electrode of the piezoelectric element 40. Incidentally, the number of signal lines 8a, and the number and position of support members

8c are appropriately changed depending on the number of electrodes of the piezoelectric element 40 or the position of vibration node.

The piezoelectric element 40 is structured generally the same as the piezoelectric element 10 except for an electrode extended to an end face.

As described above, in accordance with ~~the~~ the inventive ultrasonic motor 4 ~~reduced is leak amount to the outside of~~ the loss of the expansion-and-contraction and flex vibration caused on the piezoelectric element 40 is reduced as compared to the conventional~~, similarly to the~~ ultrasonic motor 1. Furthermore, because the support member 8c is provided in a manner holding a flex vibration node of the piezoelectric element 40, ~~further reduced is the leak~~ the amount ~~to~~ of loss of the ~~outside of~~ flex vibration caused in the piezoelectric element 40 is further reduced.

Accordingly, the ultrasonic motor 4 efficiently delivers a drive force produced on the piezoelectric element 40 to the moving member.

Also, the piezoelectric element 40 is mounted through solder on the surfaces of the support members 8c. Accordingly, where for example the circuit board 8 is formed by a printed board, it is possible to mount the piezoelectric element 40 on the circuit board 8 in a similar procedure to conventional mounting of a transistor or capacitor on the board. That is, the ultrasonic motor 4 allows on-board mounting using an

existing electric circuit production line, reducing mounting cost and improving reliability.

Incidentally, the support member 8c may be provided with a constriction similarly to the support member 21 or the support member 8c only may be formed of a conductive rubber. In this case, because the piezoelectric element 40 is pushed against the moving member by the support member 8c, the transmission efficiency of drive force to the moving member further improves.

Also, the support member 8c may be provided with an entire or one part of an electric circuit, such as a self-oscillation circuit.

[Third Embodiment]

Fig. 7 is a block diagram illustrating of an electronic appliance with an incorporating embodiment of the inventive ultrasonic motor 5 that the ultrasonic motor of the present invention is applied to an electronic appliance.

An electronic appliance with an ultrasonic motor 5 is realized by providing a piezoelectric element 51 treated by a predetermined polarization process, a vibration member 52 joined to an piezoelectric element 51, a moving member 53 to be moved by the vibration member 52, a pressurizing mechanism 54 for applying pressure to the vibration member 52 and moving member 53, a transmission mechanism 55 movable interlinked to the moving member 53, and an output mechanism 56 to be moved based on operation of the transmission mechanism 55.

Incidentally, the pressurizing mechanism 54 is, for example, provided by the support member 21.

Here, the electronic appliance [with] incorporating an embodiment of the inventive ultrasonic motor 5 includes, for example, electronic timepieces, measuring instruments, cameras, printers, printing machines, machine tools, robots, moving apparatuses, memory devices and so on.

Also, the piezoelectric vibrator 51 uses, for example, piezoelectric elements 10, 20, 30. Also, the transmission mechanism 55 uses, for example, a transmission wheel, such as a gear, friction wheel, or the like. The output mechanism 56 uses, for example for a camera, a shutter drive mechanism or lens drive mechanism, and for an electronic timepiece, a pointer drive mechanism or calendar drive mechanism. Where used in a memory device, a head drive mechanism for driving a head to read and write information from and to a memory medium within the information memory device. For a machine tool, a tool feed mechanism or work feed mechanism is used.

[Because this] The electronic appliance [with] incorporates an ultrasonic motor 5 [uses a ultrasonic motor] constructed according to the present invention having a higher output as compared to the conventional ultrasonic motor, and thus the ultrasonic motor and its drive circuits are reduced in size. Accordingly, [it] the electronic appliance is smaller in size as compared to [the] a similar conventional electronic appliance. Also, where a self-oscillation drive is employed as a method to drive the

ultrasonic motor, it is possible to further reduce the size for

incorporating an inventive

the electronic appliance [with] ultrasonic motor 5.

Further

[Incidentally], if an output axis is provided to the moving member 53 to make a structure having a power transmission

for transmitting

mechanism [to transmit] torque through the output axis, a drive

obtained using

mechanism is [structured by] a single ultrasonic motor.

According to this invention, because the drive signal is transmitted through the support member to the piezoelectric

provide

vibrator, there is no need to separately [providing] a signal transmission part. Accordingly, the expansion-and-

loss of the

contraction vibration and flex vibration caused on the piezoelectric vibrator is reduced [in leak amount to an outside] as compared to the conventional. Therefore, the ultrasonic

ultrasonic motor

motor according to the invention efficiently transmit a drive

present

force caused on the piezoelectric vibrator to the moving member.

in accordance with the present invention

the necessity

Also, [the unnecessity] of separately providing a signal

inventive

transmission part [offers size reduction for] the ultrasonic

is avoided thus reducing the size of

motor and [hence decrease in] the number of manufacture processes

a decreasing

resulting in reduction in manufacture cost.

[Further, according to this invention, a function is available equivalent to that of the above invention. In

In accordance with the present invention,

addition] the piezoelectric vibrator is urged on the moving member by the elasticity of the support member. Accordingly,

the drive force caused on the piezoelectric vibrator is transmitted to the moving member with higher efficiency.

Further, according to this invention, the provision of the constriction in the support member reduces the vibration transmission area [in the support member so that the

and reduces vibration loss,

constriction reduces the leak of vibration furthermore.] Consequently, the ultrasonic motor transmits a drive force to the moving member with higher efficiency. Furthermore, the support member has elasticity due to the constriction, and has an operation equivalent to that of the above invention.

in accordance with the present invention

Further, [acceding to this invention], because the support member is [one] part of the substrate, the ultrasonic motor is easy to mount on the substrate.

[Further, according to this invention, a similar operation is available to that of the above invention.] In addition, there is a decrease in thickness of the ultrasonic motor plus the substrate. Accordingly the application of the ultrasonic motor is broadened as compared to the conventional ultrasonic motor.

in accordance with the present invention

a

the

inventive

a compared with the conventional art

[Further, according to this invention, a similar operation is available to that of the above invention.] In addition, because the piezoelectric vibrator is mounted on the support member, the piezoelectric vibrator can be mounted on a substrate in a similar procedure to conventional mounting of transistors or capacitors on a substrate. That is, in the ultrasonic motor of the present invention, it is possible to

accordance with

simultaneously mount a motor and circuits on a substrate by using an existing electric circuit production line.

inventive lower

9 Accordingly, the ultrasonic motor is reduced in mounting cost

a more stabilized

11 and stabilized in mounting process.

Further, according to this invention, because the support member is provided with at least part of a drive circuit, there

a in the

7 is reduction of variation in ultrasonic motor performance resulting from mounting of the piezoelectric vibrator and the drive circuit, improving the reliability.

Further, according to this invention, because the support member holds the piezoelectric vibrator at a point corresponding to a node of flex vibration, there is further

a lost

13 decrease in externally leaking amount of vibration caused on the piezoelectric vibrator. Consequently, the ultrasonic motor can transmit a drive force caused on the piezoelectric vibrator to the moving member with higher efficiency.

Further, according to this invention, because the aforesaid ultrasonic motor is used in which less vibration

is lost

14 leaks to an outside as compared to the conventional ultrasonic motor, the ultrasonic motor is increased in output. That is, the ultrasonic motor and its drive circuit are reduced in size, hence the electronic appliance with ultrasonic motor is decreased in size.